EE 221 Circuits II

MARCH 4, 2019

Lecture 11

Introduction to freq. response

$$\frac{1}{1+ja\cdot f\cdot c\cdot d}=$$

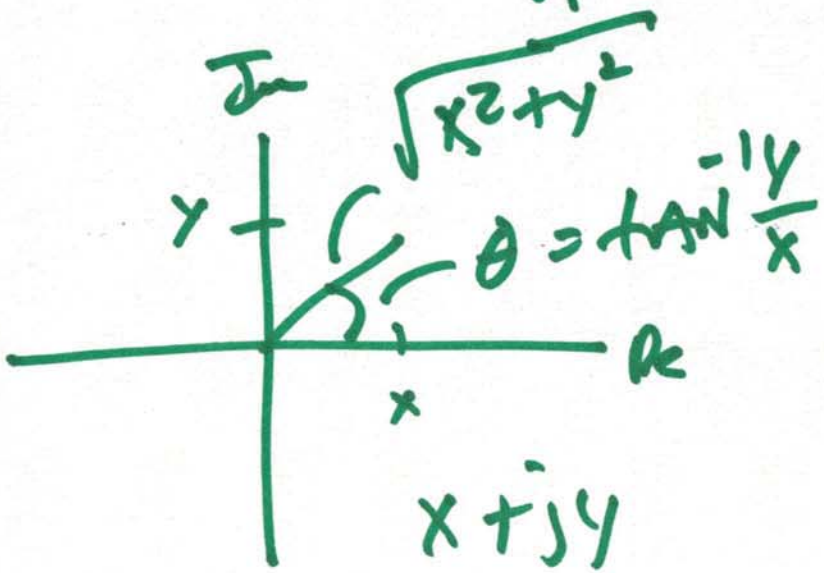
$$\frac{1}{1+j\cdot f\cdot\frac{1}{acd}}=$$

$$f_p=\frac{1}{acd}$$

$$\frac{1}{1+j\frac{f}{f_p}}$$

$$\frac{v_{out}}{v_{in}} = \frac{1}{1 + j\frac{f}{f_p}} \Rightarrow \left|\frac{v_{out}}{v_{in}}\right| = \frac{1}{\sqrt{(1)^2 + \left(\frac{f}{f_p}\right)^2}}$$

$$\angle\frac{v_{out}}{v_{in}} = -\tan^{-1}\frac{f}{f_p}$$



$$\frac{1}{a+jb} \cdot \frac{a-jb}{a-jb} \leftarrow \text{complex conjugate}$$

$$\frac{a-jb}{a^2+b^2} = \underbrace{\frac{a}{a^2+b^2}}_{x} + j\underbrace{\frac{-b}{a^2+b^2}}_{y}$$

$$\sqrt{\left(\frac{a}{a^2+b^2}\right)^2 + \left(\frac{-b}{a^2+b^2}\right)^2}$$

$$\sqrt{\frac{a^2+b^2}{(a^2+b^2)^2}} = \frac{1}{\sqrt{a^2+b^2}}, \quad \theta = \tan^{-1}\frac{\frac{-b}{a^2+b^2}}{\frac{a}{a^2+b^2}} = -\tan^{-1}\frac{b}{a} = \tan^{-1}\frac{-b}{a}$$

2)

$$\left|\frac{1}{1+j\frac{f}{f_p}}\right| = \frac{1}{\sqrt{1+\left(\frac{f}{f_p}\right)^2}}$$

$\rightarrow f=f_p \rightarrow |\cdot| = \frac{1}{\sqrt{2}} = 0.707$

$= -3dB$

$\angle\theta = -\tan^{-1}\frac{f}{f_p}$

$f = \frac{f_p}{10} \Rightarrow -\tan^{-1}\frac{1}{10} \simeq 0$

$f = f_p \Rightarrow -\tan^{-1}1 = -45°$

$f = 10f_p \Rightarrow -\tan^{-1}10 = -90°$

$f << f_p \rightarrow |\cdot| \simeq \frac{1}{1} = 1$

$dB = 20\cdot\log\frac{1}{1} = 0dB$

$f >> f_p \rightarrow |\cdot| \simeq \frac{1}{\frac{f}{f_p}} = \frac{f_p}{f}$

EX:

$f_p = 100\ Hz$

$f = 100\cdot f_p = 10\ KHz$

$|\cdot| = \frac{1}{100} \rightarrow -40\ dB$

$f = 10\cdot f_p = 1KHz$

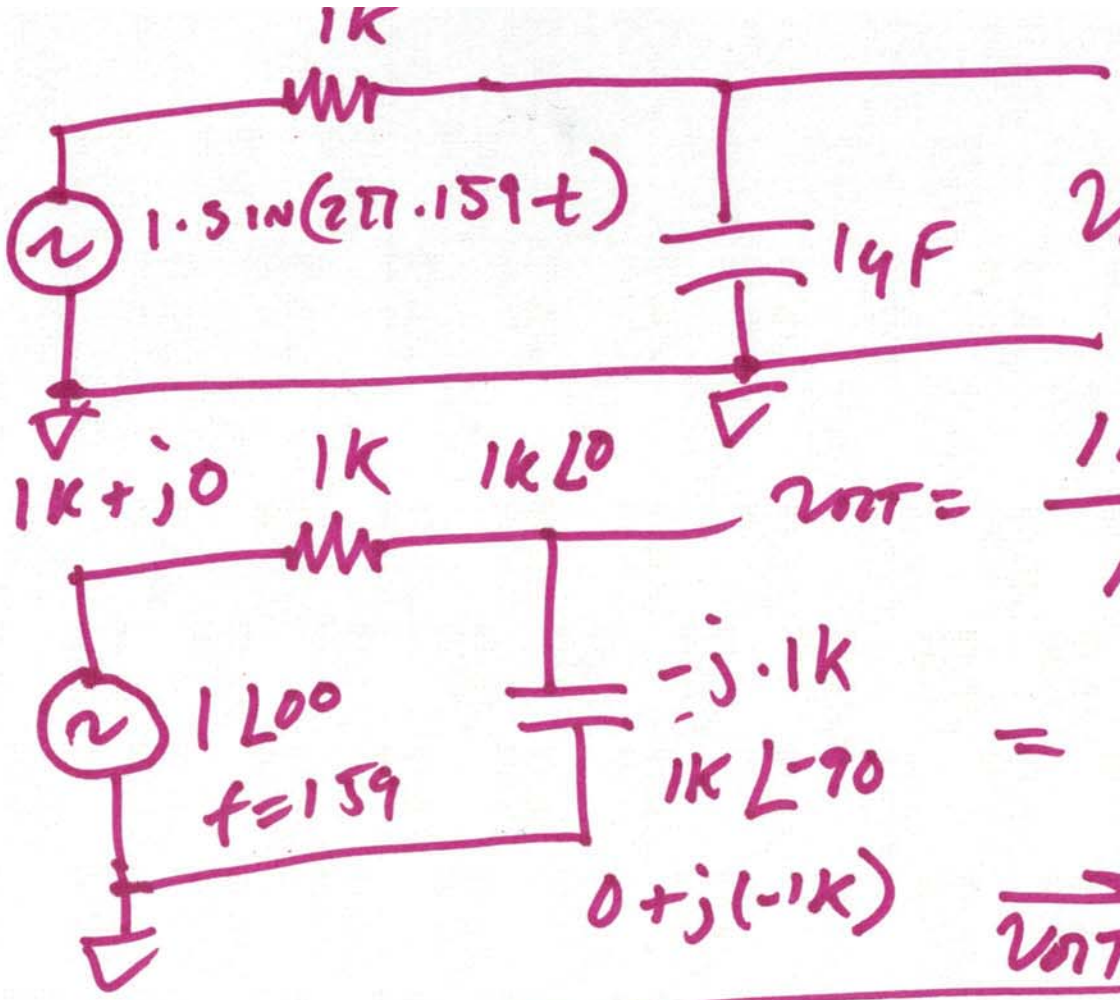
$|\cdot| = \frac{1}{10}$

$= -20dB$

$-20dB = 20\log 10^{-1} = 20\log\frac{1}{10}$

+40dB = x100
+20dB = x20
+14dB = x5
0dB = x1
-3dB = x.707
-6dB = x$\frac{1}{2}$

+6dB = x2
-20dB = x$\frac{1}{10}$



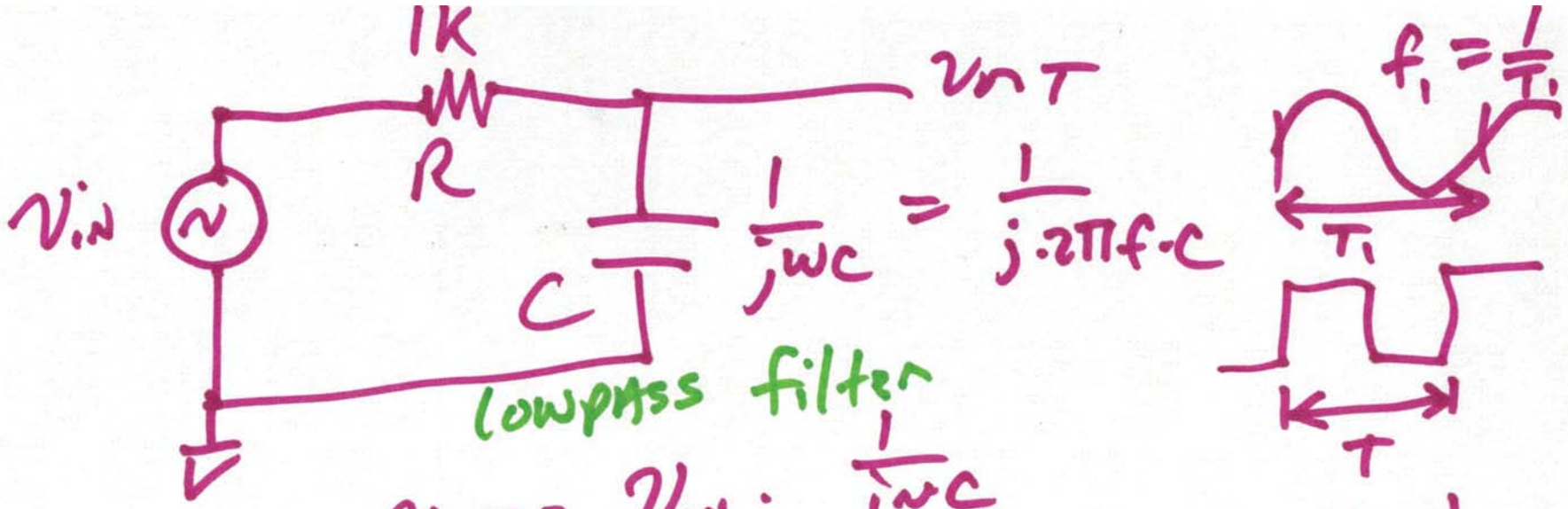
$$Z_C = \frac{-j}{2\pi f \cdot C}$$

$$V_{OUT} = \frac{1L0^\circ \cdot 1kL-90^\circ}{1K + j(-1K)}$$

$$= \frac{1kL-90^\circ}{1.4kL-45^\circ}$$

$$\overrightarrow{V_{OUT}} = 0.707L-45^\circ$$

$$\boxed{V_{OUT}(t) = 0.707 \sin(2\pi \cdot 159t - 45^\circ)}$$



$$v_{out} = v_{in} \cdot \frac{\frac{1}{j\omega C}}{\frac{1}{j\omega C} + R} \qquad f = \frac{1}{T}$$

$$\frac{v_{out}}{v_{in}} = \frac{1}{1 + j2\pi f \cdot RC} = \frac{1}{1 + j\frac{f}{f_p}}$$

$$f_p = \frac{1}{2\pi RC}$$

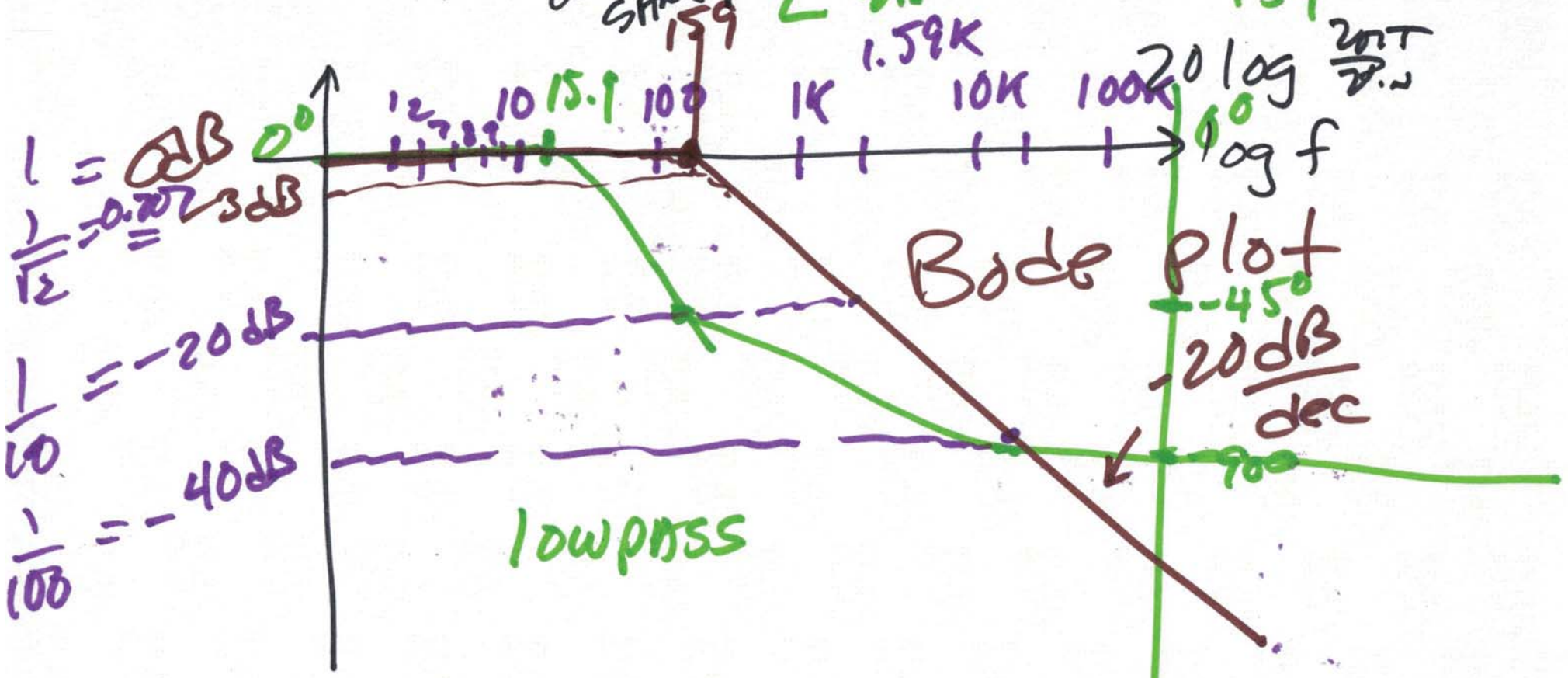
$$f_p = \frac{1}{2\pi \cdot 1k \cdot 10^{-6}}$$

$$= 159\,Hz$$

$$\left|\frac{V_{out}}{V_{in}}\right| = \frac{1}{\sqrt{1+\left(\frac{f}{f_p}\right)^2}} = \frac{1}{\sqrt{1+\left(\frac{f}{159}\right)^2}}$$

$$\angle\frac{V_{out}}{V_{in}} = -\tan^{-1}\frac{f}{159}$$

log Allow Showing big And small things on the same plot!

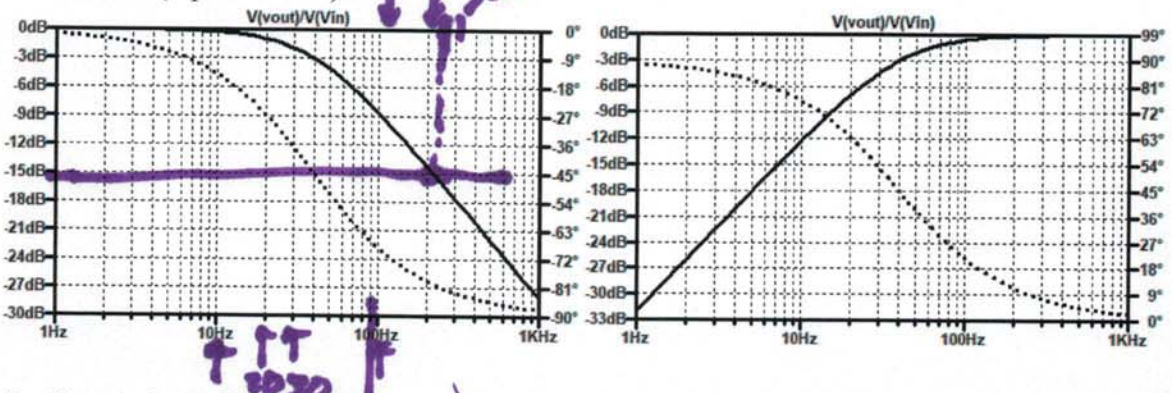


due MARch 11, Lec 13

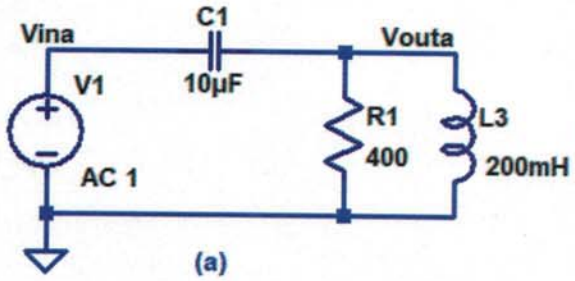
H.W. #11 EE 221 Spring 2019

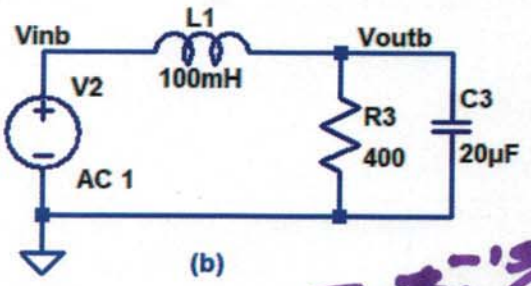
Show your work for credit and put a box around each of your answers (follow the hw guidelines!)

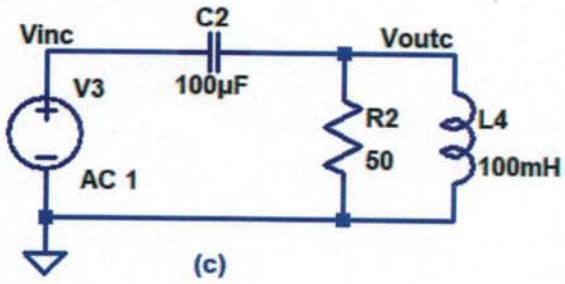
1. Examine the frequency response plots seen below. If the input to each of the corresponding circuits is a 2V peak signal with a frequency 60 Hz hand sketch the input and output of the circuits. (2 points each)

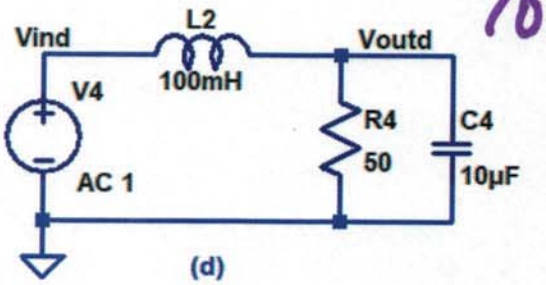


2. Sketch the Bode responses, both magnitude and phase, for the following circuits. Verify yours answer using LTspice. (8 points)







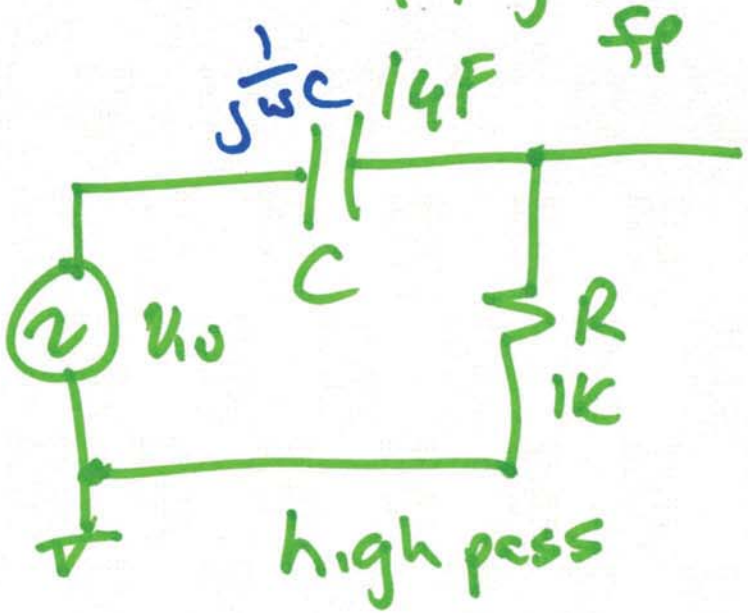


Where does the more pole & zero come from?

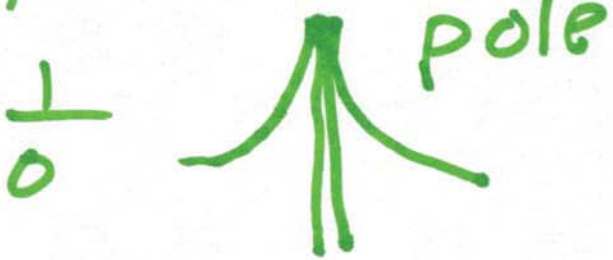
$$\frac{v_{oT}}{v_{in}} = \frac{1 + j\frac{f}{f_z}}{1 + j\frac{f}{f_p}} \Rightarrow$$

$f = -f_z$

Add to zero



$f = -f_p$



$$\frac{v_{oT}}{v_{in}} = \frac{R}{R + \frac{1}{j\omega C}}$$

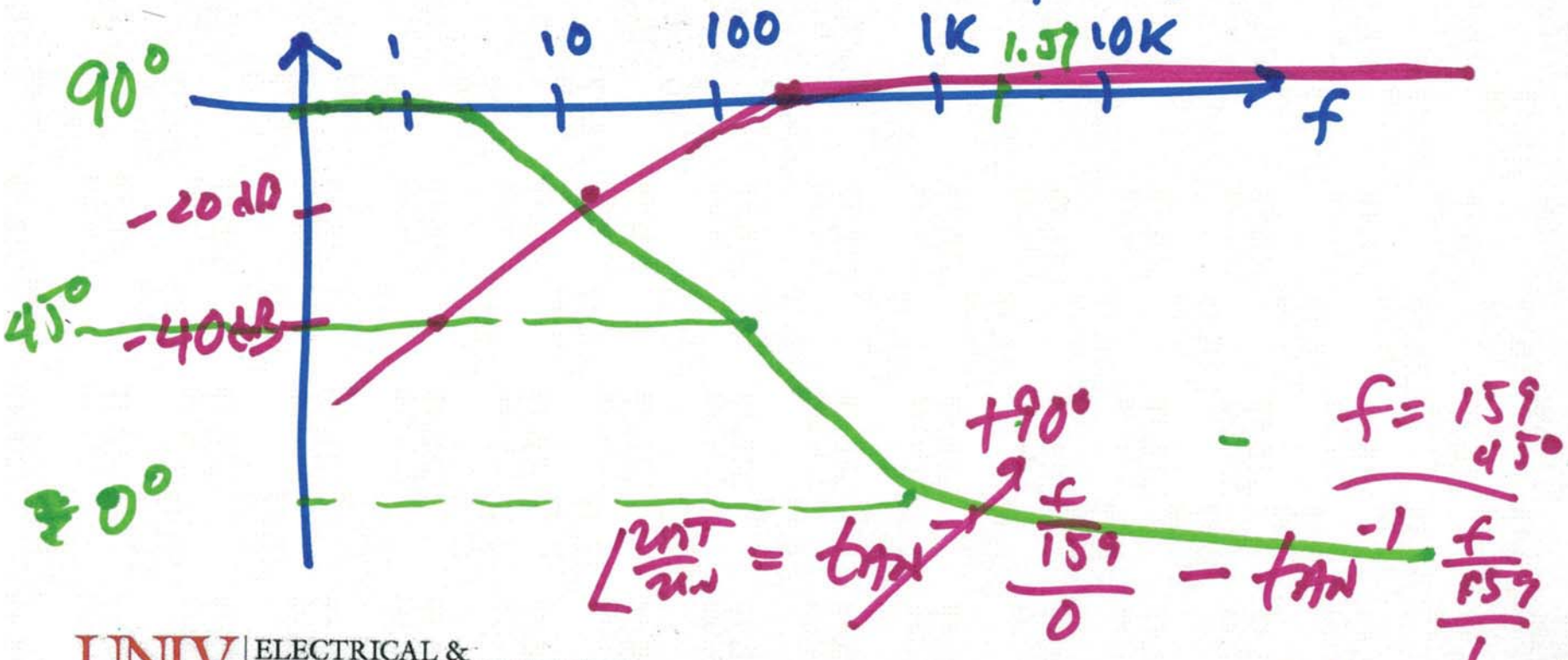
$$\frac{v_{oT}}{v_{in}} = \frac{0 + j\frac{f}{\frac{1}{2\pi RC}}}{1 + j\frac{f}{\frac{1}{2\pi RC}}} = \frac{0 + j\omega RC}{1 + j\omega RC} = \frac{0 + j2\pi fRC}{1 + j2\pi fRC}$$

$$\frac{1}{2\pi RC} = 159$$

$$\frac{V_{OUT}}{V_{IN}} = \frac{0 + j\frac{f}{159}}{1 + j\frac{f}{159}}, \quad \left|\frac{V_{OUT}}{V_{IN}}\right| = \frac{\frac{f}{159}}{\sqrt{1 + \left(\frac{f}{159}\right)^2}} \approx \frac{f}{f_{-3dB}} \text{ for } f \ll 159$$

$f = 15.9\ Hz \quad \left|\frac{V_{OUT}}{V_{IN}}\right| \approx \frac{1}{10} = -20\ dB$

$f = 1.59\ Hz \quad \left|\frac{V_{OUT}}{V_{IN}}\right| = \frac{1}{100} = -40\ dB$



$$f = 70\,Hz \qquad \left|\frac{v_{out}}{v_{in}}\right| = -8\,dB$$

$$-8\,dB = 20\log\left|\frac{v_{out}}{v_{in}}\right|$$

if $v_{in} = 2\sin 2\pi 70 \cdot t$ $\qquad \left|\frac{v_{out}}{v_{in}}\right| = 10^{-8/20}$

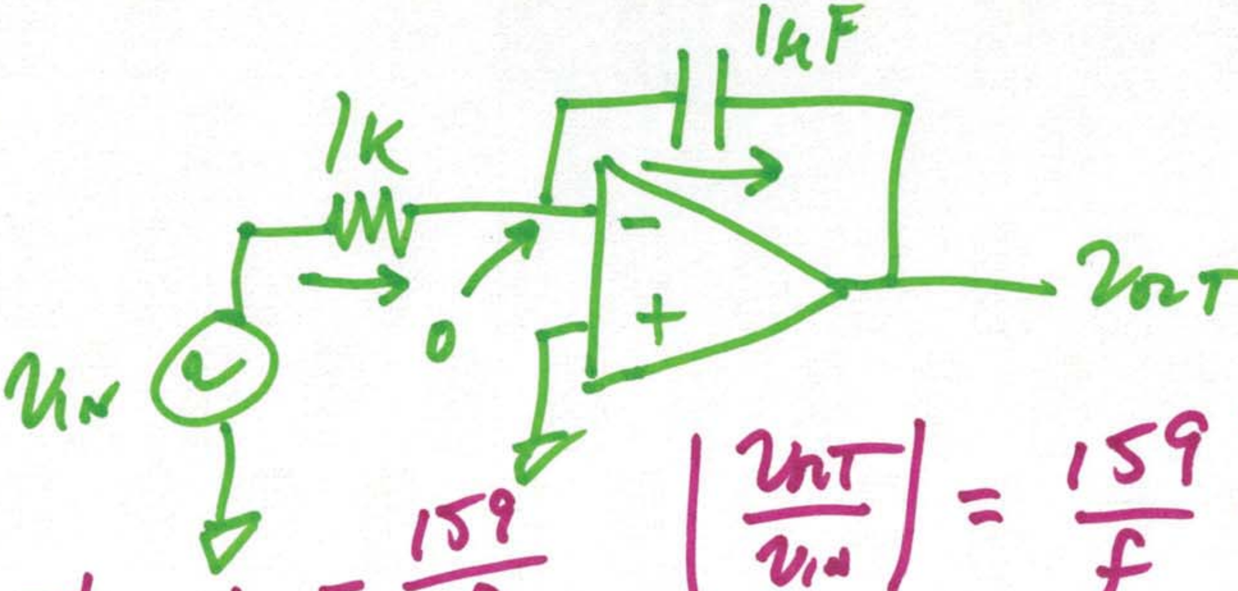
$v_{out} = 0.8\sin(2\pi \cdot 70 \cdot t + 70°)$ $\qquad = 0.4$

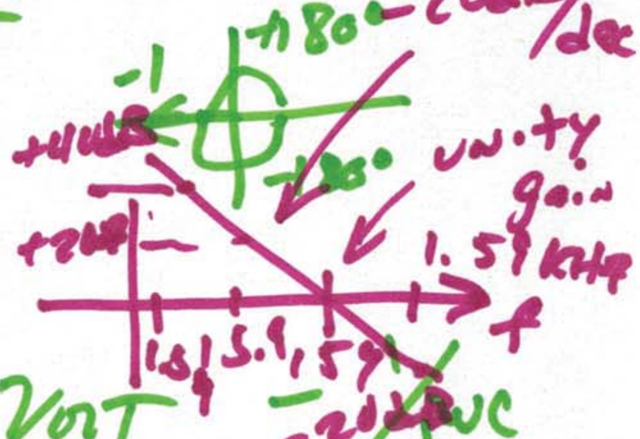
$$\angle 70° = \angle\frac{v_{out}}{v_{in}}$$

$$70 = 360 \cdot \frac{t_d}{T} = 360 \cdot t_d \cdot f$$

$$t_d = \frac{70°}{360° \cdot 70\,Hz} = 2.78\,ms$$

AC Resp.





$$\left|\frac{v_{OUT}}{v_{IN}}\right| = \frac{159}{f}$$

$$\left|\frac{v_{OUT}}{v_{IN}}\right| = \frac{1}{\frac{f}{159}} = \frac{159}{f}$$

$$\frac{v_{IN}}{R} \Rightarrow \frac{0 - v_{OUT}}{1/j\omega C} \qquad \frac{v_{OUT}}{v_{IN}} = \frac{-1/j\omega C}{R}$$

$$\frac{v_{OUT}}{v_{IN}} = -\frac{1}{j\omega RC} = \frac{-1}{0 + j\cdot\frac{f}{2\pi RC}} = \frac{-1}{0 + j\frac{f}{159}}$$

$$\angle\frac{v_{OUT}}{v_{IN}} = 180 - \tan^{-1}\frac{f/159}{0} = \underline{\underline{+90^\circ}}$$

$\tan^{-1}\frac{f/159}{0} \rightarrow 90^\circ$